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The Effect of Heating Process using Electric and Gas Ovens on Chemical and Physical Properties of Cooked Smoked-Meat

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Abstract

Study of potential of kenari (*Canarium indicum* L.) shell as a raw material in liquid smoke production for meat flavor developer has been done. To achieve this study, heating method using electric and gas ovens on the properties of the cooked smoke-meat have been carried out. The characterization of chemical properties (water content, protein content, fat content, TBA and the number of peroxide, physical properties (cooking loss, WHC, tenderness, color) cooked smoke-meat were analyzed using the Independent-Sample T Test. The results showed that protein and water contents as well as physical properties of electric oven- and gas oven-heated-cooked smoked meats were relatively the same. Fat content of electric oven-heated-cooked smoked meat was higher than that of oven gas-heated-cooked smoked meat. The TBA and peroxide values of electric oven-heated-cooked smoked meat were lower that gas oven-heated-cooked smoked meat.

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Keywords: kenari shell, liquid smoke, electric oven, gas oven, cooked smoked-meat.

INTRODUCTION

The use of liquid smoke was developed in the late of 1980s in order to replace the traditional smoking process [1]. The increasing of the number of researches in the production of liquid smoke from various woods [2], coconut shell [2], *Vitis venivera* L. [3], agricultural waste [4], *Fagus sylvatica* L. [5], *Salvia lavandulifolia* [6], spice

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solid wastes [7], rubber wood [8], cassava wood [9], and oak [10]. The liquid smoke could be applied as antibacterial [11; 4; 12; 13], antioxidant [11; 4; 14; 15], preservative [16]. The liquid smoke is also used to organoleptic or sensory [7; 9; 17], texture [18; 19], physicochemical [20; 19], chemical and microbiological [17], benzo(a)piren content [9; 21].

The utilization of liquid smoke on meat to replace the traditional smoking leads the volatile compounds to be deposited on the surface. The meat does not obtain enough heat, thus it is still raw. Based on those points of view, the further treatments, such as heating, should be conducted so the smoked meat could be readily eaten.

Low temperature and long time heating at ≤ 110°C could be the alternative process to heat the meat [22]. Temperature of 80°C is the ideal and popular one as the meat would have appropriate tenderness on the quality assay [23].

Heating process using electrical and gas ovens could be done by low-moderate society. Heating using both electric and gas ovens at the same temperature was expected to produce the same characteristics of cooked meat. The question would be whether the heating time of raw meat using an electric oven and gas oven would be the same. The heat source of electric oven was rod element equipped on the top and bottom sides of the oven. The element will smolder if the oven is turned on. The employed element is only the bottom one. The heat propagation on the electric oven is conduction (heat transfer from heat source to tray) and convection (heat transfer from the surface to the inside of meat). The heat source of gas oven is gas fuel. The fire from gas stove is put at the bottom of oven. The heat propagation is conduction (heat transfer from the oven chamber to tray) and convection (heat transfer from the surface to the inside of meat).

The heating at the same oven and internal temperatures of could probably give the pH, water, protein and fat contents of cooked smoked meat since the employed energy is same. The energy could only evaporate air and not destroy the molecules of meat. The fat content, peroxide number and TBA value are predicted to be different if the heating time is different. Fat could melt at range of 37-40°C. On the other word, the quantity of melted fat would increase as the increase of the heating time. Concentration of Fe^{2+} sharply increases during the process and leads the fat oxidation. Therefore, both peroxide and TBA values would increase.

A physical property of cooked smoked meat that is prepared by using electric oven is predicted to be the same as that using gas oven. The physical properties of meat are closely related to the chemical properties, particularly water and protein contents of meat.

MATERIAL AND METHODS

Preparation of Liquid Smoke

Production of liquid smoke was done by pyrolysis. Pyrolysis furnace was equipped with a 1500 watt electric heater encircling reactor with a diameter of 20 cm and height of 40 cm which could be charged with as much as 4 kg of materials. Reactor cover was connected by pipeline to the cooling tubes used to condense the fumes

and generate the liquid smoke. After all materials inserted into the furnace, it was then closed, condenser was set and cooling tube was streamed with cold water. Pyrolysis was carried out at a temperature of 420 °C for 100 minutes [8]. The obtained liquid smoke was centrifuged in 4000 rpm for 20 minutes [24]. Kenari shell liquid smoke was diluted 1 part of liquid smoke: 2 parts of aquabidest (the results of previous research) [25].

Preparation of Meat

Longissimus dorsi beef was separated from the carcass and packed using vacuum with polypropylene plastic then stored in freezer for 48 hours. After that, the beef was stored in a cold room (3° - 4°C) then was cut into small piece of about 5 cm x 5 cm x 2 cm [25].

Pieces of *Longissimus dorsi* beef which had been prepared was placed in submersion container which was then added with solution of liquid smoke with different dilution levels until all the meat samples was immersed (the ratio of liquid smoke and meat samples = 1:1). The submersion was performed for 15 minutes. After the submersion had been done, the meat was drained until no longer dripping solution.

Preparation oven

Preparation oven was carried out as follows: the electric and gas ovens were assembled with modified thermo control. Thermo control was connected with an electric oven and a power source, while the thermocouple is inserted into the electric oven. In principle, the assembly of gas oven was similar with that of electric oven. In gas oven, there was only an additional tool (solenoid valve) mounted on the gas hose to regulate the size of the gas flow automatically. Electric and gas ovens was heated to 110°C. Having finished the preparation of liquid smoke, meat and oven, the immersion on diluted liquid smoke was performed for 15 minutes and drained. Raw smoked meat was put into the oven at temperature of 110°C. Calculation of the heating time was begin at 110°C and the temperature was monitored every 15 minutes until ± 80°C. Each treatment was done in 6 (six) replicates.

Data Collection

Analyses done included pH analysis by potentiometric method [26], water, fat and protein content of smoked beef (performed by using foodscan analyzer), the color analysis using Minolta colorimeter (parameter L, a, and b), tenderness using the universal testing instrument (Lloyd), water holding capacity using modified Hamm method [27].

Data Analysis

The pH, moisture, fat, protein contents, TBA, peroxide number, color, cooking loss, water holding capacity, tenderness, and the number of bacteria on cooked meat were analyzed using the Independent-Sample T Test [28].

RESULTS AND DISCUSSION

The effect of heating process using electric and gas ovens on physical and chemical properties of cooked smoked-meat

Physical and chemical properties of raw meat and raw smoked-meat were presented in Table 1.

The values of pH, water, protein, fat contents number of peroxide and TBA of cooked smoked meat which was heated using either electric or gas ovens were presented in Table 2.

pH

The pH value of electric oven-heated-cooked smoked meat was not different with that of gas oven-heated-cooked smoked meat. The pH was lower than that of liquid smoke-smoked-cow tongue (6.36) [20]. The value met the Turkish standard quality of cow tongue (5.0-6.5). Such differences could be probably caused by the differences on raw material and the content of liquid smoked. The difference on pH might probably due to the difference of organic acid content on the liquid smoke [20].

Water content

Water content of cooked smoked meat (Table 2) was lower than raw and smoked meats (Table 1). The results were in line with the research which stated that the water content of meat that thermally treated was lower than the raw meat [29]. Additionally, the content depended on the heating method and the final temperature.

Water contents of electric oven- and gas oven-heated-cooked smoked meats were not significantly different. They were 62.06 and 64.01%, respectively. The water contents were higher compared with our results. The water contents of liquid smoke-treated-cow tongue and smoked cow tongue were 52.93 and 52.01%, respectively [20].

Protein content

Protein contents of electric oven- and gas oven-heated-cooked smoked meats were not significantly different. The results indicated that the heating method at 110°C did not affect the protein content of cooked smoked meat. Denaturation of protein occurred during the heating. This process would have low effect on the decrease on nutrient content, unless the product was heated at high temperature which could lead the degradation of amino acid of protein [30].

Fat content

Fat content of cooked smoked meat (Table 2) was higher than raw and smoked meats (Table 1). The results

were similar with our results which stated that the fat content of meat that thermally treated was higher than the raw meat [29].

Fat content of electric oven-heated-cooked smoked meat was higher ($P<0.05$) than that of oven gas-heated-cooked smoked meat. Such difference might probably due to the difference on heating time. The heating time for gas oven was longer, thus it could melt the fat in bigger amount. The employed temperature (110°C) was higher than the melting point of fat (37-40°C) [30].

Peroxide number

Peroxide number of cooked smoked meat which was heated using electric oven was lower ($P<0.05$) than that using gas oven. The concentration of Fe^{2+} increased dramatically during the cooking and could lead the oxidation of fat on the meat. The pigment of heme was the source of Fe because of its properties of thermally degradable and oxidation catalyst. The increase on concentration of non heme iron after the cooking was caused by the release of iron from the porfirin ring of heme. The slow heating rate could release more iron from the heme comparing with the fast one [31].

The heating at high temperature caused the mioglobin of meat underwent the oxidative degradation and reacted with the peroxide from PUFA on meat. The product displayed antioxidant activity [32]

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TBA

TBA value of cooked smoked meat which was heated using electric oven was higher ($P<0.05$) than that using gas oven as the heating time for gas oven was longer. It was reported that the meat which was heated at higher temperature for longer time would have lower TBA comparing with the treatment at low temperature and fast heating process [31] .

Results of physical property analyses (cook loss, water holding capacity, tenderness, color) of kenari shell liquid smoke-immersed-meat and electric- as well as gas oven-heated-meat were presented on Table 3.

Table 1: Physical and chemical properties of raw meat and raw smoked-meat

Variable	Raw meat	Raw smoked meat
pH	6.25	5.18
Water content (%)	71.28	71.04
Protein content (%)	22.49	22,89
Fat content (%)	3.31	3.84
number of peroxide (meq/kg)	1.71	0.86
TBA (mMalomaldehyde/kg)	3.40	1.11
Water holding capacity (%)	27.56	23.50
Tenderness (N)	1.06	1.49

Table 2: Chemical of cooked smoked meat

Variable	Heating	
	Electric oven	Gas Oven
pH[ns]	5.54	5.48
Water content (%)[ns]	62.06	64.01
Protein content (%)[ns]	28.03	27.07
Fat content (%)*	4.94	4.76
Peroxide number (meq/kg)*	2.04	2.28
TBA (mMalomaldehyde/Kg)*	0.19	0.43

ns = *not significant*

* = significant difference (P<0.05)

Cooking loss

Cooking loss of electric oven- and gas oven-heated-cooked smoked meats were not significantly different as the oven and internal temperatures were same. The loss was significantly affected by heating method and final internal temperature [29]. The longer cooking time, the higher loss on the liquid of meat would be, until it reaches constant value [23].

Cooking loss has a correlation with water, protein and fat contents of cooked smoked meat. The water and protein contents of either electric- or gas oven-heated-meat were same, while the fat content was different. During the heating, the ability of protein to bind water decreased. Fat could reduce the release of liquid due to the occurrence of translocation of fat along the perimisial bound tissue [23]. Moreover, the loss has correlation with water holding capacity and tenderness. The increase of water holding capacity could decrease the loss and tenderness.

Water holding capacity

Water holding capacities of electric oven- and gas oven-heated-cooked smoked meats were not significantly different. They were 32.85 and 31.49%, respectively. The capacity was correlated with the protein content [23], pH [33], tenderness, color, juiciness and cooking loss [34]. The treatment using gas oven led the protein of meat to bind more volatile compound, thus, it could not bind much water. Volatile compound of electric oven- was lower than that of gas oven-heated-cooked smoked meat. The water holding capacity was inversely correlated with the concentration of carbonyl and phenolic compound on the smoked product [35].

Tenderness

Tenderness of electric oven- and gas oven-heated-cooked smoked meats were not significantly different because heating temperature, pH, water and protein contents of cooked smoked meat heating using either electric and gas ovens were same. The results were similar with our result which stated that there was no difference on

Warner-Bratzler shear force (WBSF) of meat which was heated on the same internal temperature [29] . The tenderness was affected by the heating temperature [32]. The effect of pH on tenderness was various, were the higher pH would give more tenderness [23].

Table 3: Physical properties of cooked smoked meat

Variable	Heating	
	Electric oven	Gas oven
Cooking loss (%)[ns]	13.60	11.79
Water holding capacity (%)[ns]	32.85	31.49
Tenderness (N) [ns]	3.55	3.15

ns : *not significant*

CONCLUSION

Fat content of electric oven-heated-cooked smoked meat was higher than that of oven gas-heated-cooked smoked meat. The value of protein and water content as well as physical properties of electric oven- and gas oven-heated-cooked smoked meats were relatively the same. The TBA and peroxide values of electric oven-heated-cooked smoked meat were lower that gas oven-heated-cooked smoked meat.

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